

## RS-002, "PROCESSING APPLICATIONS FOR EARLY SITE PERMITS"

### ATTACHMENT 2

#### 2.4.3 PROBABLE MAXIMUM FLOOD (PMF) ON STREAMS AND RIVERS

##### REVIEW RESPONSIBILITIES

Primary - Mechanical and Civil Engineering Branch (EMEB)

Secondary - None

##### I. AREAS OF REVIEW

In this section of the site safety assessment for an early site permit (ESP) application, the hydrometeorological design basis is developed to determine the extent of any flood protection necessary for those structures, systems, and components necessary to ensure the capability to shut down a nuclear power plant or plants of specified type (or falling within a plant parameter envelope [PPE]) that might be constructed on the proposed site and maintain it/them in a safe shutdown condition. The areas of review include the probable maximum precipitation (PMP) potential and precipitation losses over the applicable drainage area, the runoff response characteristics of the watershed, the accumulation of flood runoff through river channels and reservoirs, the estimate of the discharge rate trace (hydrograph) of the PMF at the plant site, the determination of PMF water level conditions at the site, and the evaluation of coincident wind-generated wave conditions that could occur with the PMF. Included is a review of the details of design bases for site drainage (which is summarized in safety assessment Section 2.4.2); a review of the runoff for site drainage and drainage areas adjacent to the plant site, including the roofs of safety-related structures, resulting from potential PMP; and a review of the potential effects from erosion and sedimentation. The analyses involve modeling of physical rainfall and runoff processes to estimate the upper level of possible flood conditions adjacent to and on site.

Regulatory Guide 1.59<sup>1</sup> (Ref. 1) describes two positions with respect to flood protection for which a PMF estimate is necessary to determine the controlling design basis conditions. If Position 1 is chosen, all safety-related systems, structures, and components should be capable of withstanding the effects from the controlling flood design basis. Position 2 limits the review to specific safety-related structures, systems, and components necessary for cold shutdown and maintenance thereof.

##### II. ACCEPTANCE CRITERIA

Acceptance criteria for this section of this review standard address 10 CFR Parts 52 and 100 (Refs. 3 and 4) as they relate to identifying and evaluating hydrologic features of the site. The regulations at 10 CFR Parts 52 and 100 require that a site's physical characteristics (including

---

<sup>1</sup> In using Regulatory Guide 1.59, references to ANSI N170-1976 should be read as references to ANSI/ANS-2.8-1992 (Ref. 2), which has superseded the earlier document.

seismology, meteorology, geology, and hydrology) be taken into account when determining the acceptability of a site for a nuclear reactor or reactors.

To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the applicant's safety assessment should contain a description of the hydrologic characteristics of the site and region and an analysis of the PMF. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of structures, systems, and components important to safety for a nuclear power plant or plants of specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that hydrologic phenomena of severity up to and including the PMF would pose no undue risk to the type of facility proposed for the site.

For those cases where a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting limiting values of parameters. Important PPE parameters for safety assessment Section 2.4 include but are not limited to precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

Note: Though not required at the ESP stage, the applicant for a combined license (COL) will need to demonstrate compliance with General Design Criterion 2 (Ref. 5) as it relates to structures, systems, and components important to safety being designed to withstand the effects of floods.

To meet the requirements of the hydrologic aspects of 10 CFR Parts 52 and 100, the following specific criteria are used:

The PMF as defined in Regulatory Guide 1.59 has been adopted as one of the conditions to be evaluated in establishing the applicable stream and river flooding design basis referred to in General Design Criterion 2, Appendix A, 10 CFR Part 50. PMF estimates are needed for all adjacent streams or rivers and site drainage (including the consideration of PMP on the roofs of safety-related structures). The criteria for accepting the applicant's PMF-related design basis depend on one of the following three conditions:

1. The elevation attained by the PMF (with coincident wind waves) establishes a necessary protection level to be used in the design of the facility.
2. The elevation attained by the PMF (with coincident wind waves) is not controlling; the design basis flood protection level is established by another flood phenomenon (e.g., the probable maximum hurricane).
3. The site is "dry"; that is, the site is well above the elevation attained by a PMF (with coincident wind waves).

When condition 1 is applicable, the staff will assess the flood level (described in subsection III). The assessment may be made independently from basic data, by detailed review and checking of the applicant's analyses, or by comparison with estimates made by others that have been reviewed in detail. The applicant's estimates of the PMF level and the coincident wave action are acceptable if the estimates are no more than 5% less conservative than the staff's estimates. If the applicant's estimates of discharge are more than 5% less conservative than

the staff's, the applicant should fully document and justify its estimates or accept the staff's estimates.

When condition 2 or 3 applies, the staff analyses may be less rigorous (described in subsection III). For condition 2, acceptance is based on the protection level estimated for another flood-producing phenomenon exceeding the staff estimate of PMF water levels. For condition 3, the site grade should be well above the staff assessment of PMF water levels. The evaluation of the adequacy of the margin (difference in flood and site elevations) is generally a matter of engineering judgment. The judgment is based on the confidence in the flood level estimate and the degree of conservatism in each parameter used in the estimate.

Appropriate sections of the following documents are used by the staff to determine the acceptability of the applicant's data and analyses. (Ref. 6) Regulatory Guide 1.59 provides guidance for estimating the PMF design basis. Publications of the National Oceanic and Atmospheric Administration (NOAA) and the Corps of Engineers may be used to estimate PMF discharge and water level condition at the site and coincident wind-generated wave activity.

### III. REVIEW PROCEDURES

Requirements and procedures governing issuance of ESPs for approval of proposed sites for nuclear power facilities are specified in 10 CFR Part 52. Information required for such a permit includes a description of the site's hydrometeorological characteristics. For this type of permit, the scope and level of detail for reviewing such data are outlined below.

For conditions 1 and 2 (described in subsection II), the methods used for evaluating flooding potential are separated into two parts--PMF on adjacent streams and local PMF. (The procedure for evaluating the adequacy of site drainage facilities based on a local PMF is outlined in Section 2.4.2 of this review standard.) Corps of Engineers PMF assessments for specific locations, or generalized PMF assessments for a geographical area approved by the Chief of Engineers and contained in published or unpublished reports of that agency, may be used in lieu of staff-developed analyses. In the absence of such assessments, both large and small basin PMP estimates by NOAA; published techniques of the World Meteorological Organization; and runoff, impoundment, and river-routing models of the Corps of Engineers are used by the staff to estimate PMF discharge and water level at the site. A comprehensive review of the applicant's analyses will be performed and a simplified analysis using calculational procedures or models with demonstrably conservative coefficients and assumptions is performed. If the applicant's PMF estimates are within acceptable margins (described in subsection II), the staff positions will indicate concurrence with the applicant's PMF estimates and the safety evaluation report (SER) input will be written accordingly. If the simplified analysis indicates a potential problem with the applicant's estimates, a detailed analysis using more realistic techniques will be performed. The staff will develop a position based on the detailed analysis; resolve, if possible, differences between the applicant's and staff's estimates of PMF design basis; and prepare the SER input accordingly.

Wind-generated wave action will be independently estimated using Corps of Engineers criteria such as the "Coastal Engineering Manual."<sup>2</sup> (Ref. 7) When sufficient water depth is available, the significant wave height and runup are used for structural design purposes, and the one

---

<sup>2</sup> The "Coastal Engineering Manual" replaced the "Shore Protection Manual" in 2002.  
2.4.3-3

percent wave height and runup are used for flood level estimates. Where depth limits wave height, the breaking or broken wave height and runup is used for both purposes.

For condition 3 (i.e., a "dry site"--one not subject to stream flooding by virtue of local topographic considerations), the following procedures apply:

1. Use Corps of Engineers PMF estimates for other sites in the region to develop "regional drainage area versus PMF discharge " ( $\text{m}^3$  per sec/ $\text{km}^2$  ( $\text{ft}^3$  per sec/ $\text{mi}^2$ )) data, for extrapolation to the site.
2. Envelope the above data points to obtain an estimate of the PMF applicable to the site.
3. Increase the estimate based on a judgment as to the applicability of the basic estimates. An increase in the range of 10% to 50% is generally appropriate.
4. If warranted by relative elevation differences between the site and adjacent stream, estimate the flood level at the site using slope-area techniques or water surface profile computations.
5. Estimate wind (2-yr extreme windspeed) wave runup based on breaking or 1% wave heights. Criteria for estimating windspeed are discussed in ANSI/ANS-2.8-1992.
6. Compare resultant water level with plant grade and lowest safety-related facility that can be affected.

The above items of review are performed only when applicable to the site or site region. Some items of review may be done on a generic basis.

#### IV. EVALUATION FINDINGS

For ESP reviews, the findings will summarize the applicant's and staff's estimates of the peak PMF runoff rate and water level (including allowance for coincident wind-generated wave activity) at the site. If the applicant's estimates are within the criteria (described in subsection II), staff concurrence will be stated. If the staff's estimates are 5% more conservative than the applicant's estimates, if the flood conditions may adversely affect a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed on the proposed site, and if the applicant has been unable to support his estimates, a statement on use of the staff bases will be made. If the flood conditions do not constitute a design basis, the findings will so indicate.

If Regulatory Guide 1.59, Position 2, is elected by the applicant, a statement describing lesser design bases will be included in the findings with a staff conclusion of adequacy.

A sample statement for an ESP review follows:

As set forth above, the probable maximum flood (PMF) resulting from the probable maximum precipitation (PMP) on the ABC River drainage basin yielded an estimated maximum stillwater level at the planned location of the intake structure on the D & E Canal of about 1.5 m (5.0 ft) MSL.

The PMF resulting from a local PMP storm on the drainage basins for the small streams near the site yielded an estimated maximum stillwater level of about 18 m (60 ft) MSL, which is about 6 m (20 ft) below plant grade.

The local PMF resulting from the estimated local PMP was found not to cause flooding of safety-related facilities for a nuclear power plant of type specified by the applicant [or of a facility falling within the plant parameter envelope submitted by the applicant] that might be constructed on the proposed site, since the site drainage system would be capable of functioning adequately during such a storm. Catch basins would be provided as part of the storm drainage system and would be located throughout the plant site to drain local areas. The plant yard would be graded with gentle slopes away from high points at the plant buildings, and storm water would drain away from the buildings into the local streams at lower elevations.

Historical data for the proposed site are consistent with the probable maximum precipitation and flood levels identified in the safety assessment.

Therefore, the staff concludes that the site meets the flood requirements of 10 CFR Parts 52 and 100 and is acceptable.

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of ESP applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

## VI. REFERENCES

Because of the geographic diversity of plant sites and the large number of hydrologic references, no specific tabulation is given here. In general, maps, papers, and charts by the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Soil Conservation Service (SCS), Corps of Engineers; and other publications of state, federal, and other regulatory bodies, describing hydrologic characteristics and water utilization in the site vicinity and region, are referred to on an "as-available" basis.

1. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants."
2. ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites."
3. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

4. 10 CFR Part 100, "Reactor Site Criteria."
5. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
6. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."
7. "Coastal Engineering Manual," U.S. Army Engineer Waterways Experiment Station, U.S. Government Printing Office, Washington, DC (2002).